Tractor Beams for Optical Micromanipulation

Completed Technology Project (2015 - 2019)

Project Introduction

This proposal seeks support to develop methods to project propagation-invariant electromagnetic fields that can transport illuminated objects upstream against the direction of energy flow over large distances. Such fields constitute practical realizations of "tractor beams" that have long been the subject of speculation, and could find wide-ranging applications in space and planetary exploration. Among their applications, laser-based tractor beams are potentially suitable for sampling dust from comet tails and planet surfaces. Relative to mechanical systems, tractor beams offer substantially longer ranges, far fewer moving parts, and nondestructive manipulation of delicate samples. While optical tractor beams are currently classified as technology readiness level (TRL) 1, we are here proposing to advance the technology to TRL 3. In order to achieve this goal, the Principal Investigator will employ a combination of theoretical research, computer modeling, and experimental verification, with emphasis on two promising realizations of optical tractors beams: solenoid beams and optical conveyors. In particular, we will explore a novel method of hologram projection, here termed Intermediate Plane Holographic Optical Trapping (iHOT). In this technique, holograms are projected by modulating the phase of an intermediate plane in a 4-f projection system, instead of the back-focal-plane. We anticipate that iHOT will circumvent hardware limitations within the present implementation that have restricted the complexity and range of tractor beams. Furthermore, we will examine the origin of the experimentally measured optical forces on micrometer-scale colloidal and aerosol particles, enabling us to optimize the tractor beam performance. Additionally, we will apply our knowledge of long-range optical tractor beams to the microwave regime by manipulating the phase with a micromirror array.

Anticipated Benefits

Propagation-invariant electromagnetic fields constitute practical realizations of "tractor beams" that have long been the subject of speculation, and could find wide-ranging applications in space and planetary exploration. Among their applications, laser-based tractor beams are potentially suitable for sampling dust from comet tails and planet surfaces. Relative to mechanical systems, tractor beams offer substantially longer ranges, far fewer moving parts, and nondestructive manipulation of delicate samples.

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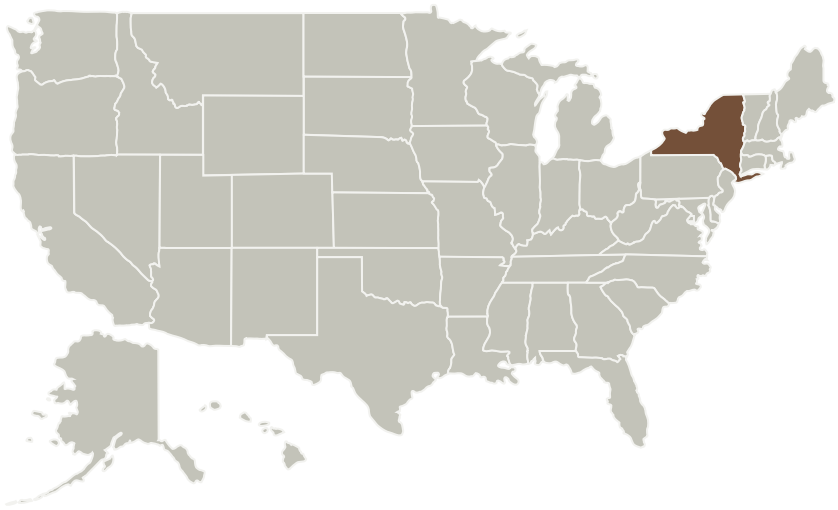
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
New York University(NYU)	Lead Organization	Academia	New York, New York

Primary U.S. Work Locations
New York

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

New York University (NYU)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

David Grier

Co-Investigator:

Aaron Yevick

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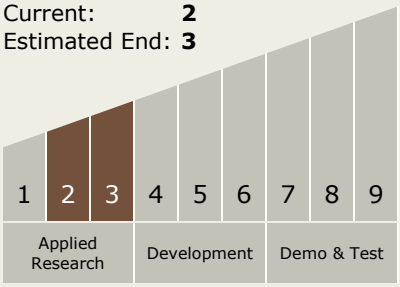
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.3 Sample Handling

Target Destinations

The Moon, Mars, Others Inside the Solar System